Geothermal and the Electricity Market in Central America

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ABSTRACT

Significant developments in the Central American electricity market have recently taken place and others are in the making. The electrical systems of six of the countries in the region, from Guatemala in the north to Panama in the south, will be interconnected when the Salvadoran grid is linked with that of Honduras, possibly in July 2002. Additional power plants are being installed or are in the planning stage (most of them using fossil fuels), and a regional electrical transmission system (the SIEPAC Line) is scheduled to be completed in 2006. The construction of pipelines to import natural gas into the region for power generation has also been proposed. These new projects and the feasibility of sending electricity across the entire region may have a significant impact on future Central American geothermal resource developments.

More geothermal power production opportunities would arise if the price of oil and gas continues to rise. Similarly, the implementation of tax benefits and other financial incentives to exploit renewable energy sources by local government and international agencies, including markets for carbon credits, would also spur geothermal development in the region.

Efforts to inform and educate local governments, and U.S. and multinational agencies about the advantages of geothermal energy have to be intensified. This should be undertaken before the Central American countries become more dependent on electricity from large fossil-fuel power plants and hydroelectric projects that are subject to uncertainties in world oil prices and climatic conditions. Local governments should also be persuaded to create incentives and put in place mechanisms that would help bring about renewable energy projects in the region.

Introduction

According to the Encyclopedia Britannica, Central America "makes up most of the tapering isthmus that separates the Pacific Ocean from the Caribbean Sea" (Figure 1). The countries of Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama are within that region (sometimes Panama is considered to be in South America because it was part of Colombia until 1903). Here, the discussion will center on the Central American Isthmus ("the Isthmus"); it includes all the Central American countries just mentioned, with the exception of Belize.

Belize, in the southeastern part of the Yucatan Peninsula, is the least developed Central American country. In 2001, the total installed electrical generation capacity was 52 MW (about half hydro and half using diesel). During that year, 293 GWh

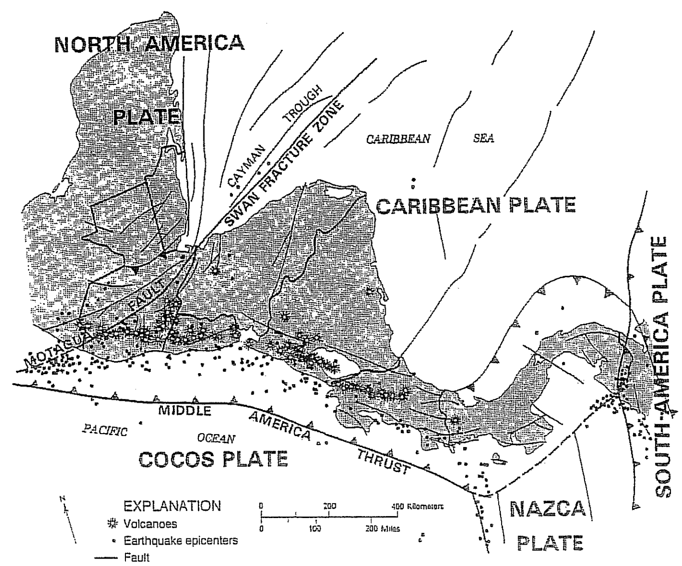


Figure 1. Simplified tectonic map of Central America (from Cunningham, *et. al.*, 1984).

Table 1. Geothermal Potential for Electricity Generation in the Central American Isthmus (data in MWe).

Country	Geothermal Potential: Range Mentioned in Publications	Geothermal Potential: Most Probable Values[1]
Costa Rica	400-3500	1000
El Salvador	400-4140	500
Guatemala	800-4000	1000
Honduras	25-500	130
Nicaragua	300-4000	1750
Panama	25-200	50
Totals	1950-16,340	4430

Note:
(1) Based on recent personal communications from G. Castillo, A. Mainieri, J.C. Palma, E. Reyes, J.A. Rodríguez and A. Zúñiga.

were generated locally and 159 GWh were imported from neighboring Mexico (Belize Electricity Limited, pers. comm., 2002). Very little is known about the geothermal resources of Belize, which are very likely to be relatively small and of low temperature. According to Cunningham et al. (1984), since the country is remote from the belt of Central American volcanoes (Figure 1), high-temperature geothermal resources – adequate for electricity generation – are not likely to be discovered.

Because of its particular geologic framework – several tectic plates interact in the region (Figure 1) – Central America is blessed with abundant geothermal resources (Table 1). Most relevant is the fast subduction of the Cocos Plate under the Caribbean Plate. This results in the uplift of land, active volcanism, and strong and frequent earthquake activity throughout much of Central America.

The paper will review the latest news on the exploration and development of the region's high-temperature (above 150°C) geothermal fields (i.e., those appropriate for electricity generation); earlier and more detailed information on these systems is available in the literature (see next section). Also discussed are recent developments in the Central America electricity system that might affect the future of geothermal in the Isthmus.

Recent News on High-Temperature Geothermal Systems in the Region

Exploration for geothermal resources in Central America has slowed significantly in the last five years or so due to a number of reasons, including:

1) governments giving investment priority to other sectors of the economy;

(2) low oil prices (i.e., mostly in the US$ 10-20 per barrel range during the last decade);

(3) privatization of the electrical sector in some countries (the private sector prefers to invest in less risky generation schemes such as hydropower and fossil-fuel power plants in deregulated electrical markets);

(4) difficulties in obtaining long-term loans (banks and private investors have become less willing to take the risks associated with the exploration and development of geothermal areas); and

(5) less support for exploration from local governments and international agencies.

At the present time, exploratory drilling is only occurring at Pailas, Costa Rica (Moya and Mainieri, 2002). Most geothermal activities in the region are focused on sustaining production at existing power plants (i.e., maintenance and repair of power plants, surface installations and wells, and drilling of development and replacement wells).

Since 1975, when the first Central American geothermal power plant was built (a 30-MW flash unit at Ahuachapán, El Salvador), the total installed geothermal electrical capacity in the region has grown to more than 400 MW (Table 2). The most recent addition is Unit 3 at Miravalles, a 27.5 MW flash plant that began generating electricity in March 2000 (Moya and Mainieri, 2002).

Table 2 illustrated that even though no new power plants were installed in 2001, the amount of geothermal electricity grew a healthy 11.8% during that year, mainly due to improved field management practices.

Recent geothermal activities at the different countries will be discussed next (from North to South; location of the fields are given in Figure 2).

Guatemala. Roldán Manzo and Palma Ayala (2000), and Lima Lobato, *et. al.,* (2000) reviewed the status of geothermal in Guatemala. There are two geothermal power plants in the country. The 26 MW (net) Zunil I binary plant and the 5 MW (net) backpressure unit at Amatitlan.

Additional development wells have been and will be drilled at Zunil to supply steam to both the existing unit and to the planned Zunil II project. Well repair activities are ongoing.

Table 2. Electricity and Geothermal in the Central American Isthmus (2000-2001)[1]

Country	Total Installed Electric Capacity (MW)	Total Installed Geothermal Capacity (MW)	Total Geothermal Electricity Generated (in GWh-net)		Increase 2000-2001	
	End of 2001	End of 2001	2000	2001	GWh-net	Percent
Costa Rica	1707	142.5	980	986	6 (2)	0.6(2)
El Salvador	1118	160	739	907	168	22.7
Guatemala	1517	33	202	202	-	-
Honduras	882	-	-	-	-	-
Nicaragua	643	70	121	188	67	55.4
Panama	1065	-	-	-	-	-
Totals	**6932 MW**	**405.5 MW**	**2042 GWh**	**2283 GWh**	**241 GWh**	**11.8 %**

Notes:
(1) Based on recent personal communications from G. Castillo, A. Mainieri, J.C. Palma, E. Reyes, J.A. Rodríguez and A. Zúñiga.
(2) The two 55-MW power plants at Miravalles were overhauled in 2001, being out of line during two months.

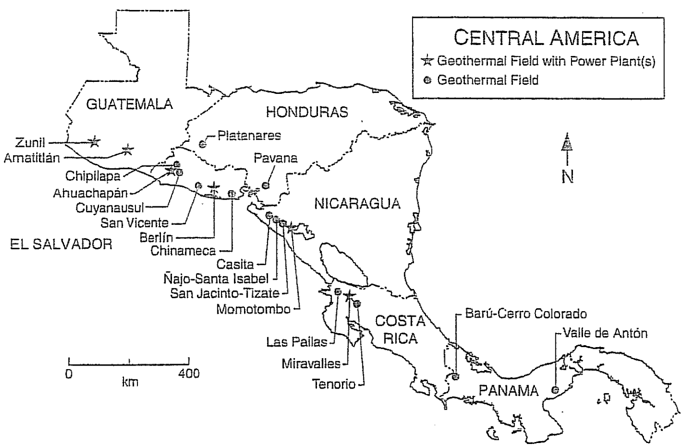


Figure 2. Central America. Location of geothermal fields and plants mentioned in the paper.

Recently, ORMAT obtained the concession to develop the Amatitlán area. The first phase of the project will be for 20-22 MW, to be expanded later to up to 50 MW. The purchase of the 5 MW backpressure plant is being negotiated (the three-year contract with Ingenieros Civiles Asociados ended in November 2001). The unit would be put back on line for about 18 months while the first phase of ORMAT's development is getting ready. Afterwards, it may be moved to the Zunil II area.

El Salvador. Rodríguez (2000) presented a country update for El Salvador at the World Geothermal Congress 2000. Drilling of new wells, repair and cleaning of older ones has continued at the Berlín and Ahuachapán fields.

The two flash plants at Berlín are on line, generating a total of 56 MW (net); two 5 MW back-pressure units in that field are on stand-by. The flash plants at Ahuachapán are generating 62 MW (gross). At present, waste geothermal fluids are injected within the field (18%), injected in the nearby Chipilapa area (55%), and the rest (27%) sent to the Pacific Ocean.

In April 2002, Enel GreenPower became the strategic partner of GESAL, the Salvadoran company that replaced the geothermal group at CEL, in the development of a third 28 MW plant at Berlín and in the exploration and possible development of the Cuyanausul field, east of Ahuachapán.

No major activities are reported at the San Vicente and Chinameca fields.

Honduras. Castillo and Salgado (2000) gave an update of Honduras' geothermal activities. No major advances have been made since then. The geochemical studies performed in 2001 at Pavana, suggesting reservoir temperatures of about 150°C, have not been expanded this year. Interest in developing Platanares, the most promising geothermal area of the country, continues.

Nicaragua. Zúñiga and Medina (2000), Klein, *et. al.*, (2001) and Zúñiga (2002) described the Nicaraguan geothermal scene. The reservoir management plan for Momotombo was reviewed and improved. New wells were drilled in the field, others were and will be cleaned and repaired, scale-inhibition systems have been installed in some of the wells, and more fluids are being injected back into the reservoir. The availability of additional steam resulted in a significant increase of power plant output, from about 12 MW in 1999 to 26 MW in April 2002. A 4 to 8 MW binary plant will be installed at Momotombo by the end of 2002. The plant will use hot waste geothermal waters before they are re-injected.

Exploration surveys have recently been completed in the Casitas geothermal area. Reservoir temperatures exceeding 225°C have been inferred based on fluid geochemistry. Drilling of deep exploratory wells is planned for 2003.

Very little or no development activities have been reported at the San Jacinto-Tizate and Ñajo-Santa Isabel concession areas.

Costa Rica. Papers by Mainieri (2000), and Moya and Mainieri (2002) give the latest news about the Costa Rican geothermal program. Miravalles, presently the largest geothermal development in the region, has four power plants with a total installed capacity of 142.5 MW. An additional 15.5 MW binary plan is scheduled to be on line in March 2004. Drilling of development (production and injection) wells continues.

The 1999-2000 exploration well program at Tenorio has not given promising data; the measured temperatures were below 160°C and the injectivity indices of the wells were low. Better results are being obtained in deep wells being drilled at the Las Pailas geothermal area, on the southern slopes of the Rincón de la Vieja volcano. Temperatures close to 240°C have been measured. The feasibility study for this area should be completed in mid-2003.

Panama. No recent reference on the status of geothermal in Panama was found; the latest is that of Ramírez (1988). The likelihood of characterizing and perhaps developing the geothermal resources of the country for electricity generation has not improved during the last years. Drilling in Valle de Antón (Díaz, *et. al.*, 2000), Panama's best geothermal prospect, was cancelled because of lack of government support. For the same reason, exploration (geology, gravimetry and geochemistry) surveys in the Barú-Cerro Colorado area have been discontinued for the time being.

The Electricity System of the Region – Recent Developments

The privatization of the region's electricity market is ongoing, but is far from complete. Honduras and Costa Rica are the Central American countries least advanced in that respect.

The total population of the six countries of the Isthmus exceeded 36 million in 2000. Only 69% of the population has access to electricity. The average annual increase in gross national production (GNP) has been about 7%. As the population, GNP and level of electrification continue to grow, an increase in electricity demand should be expected (Montesino, 2002). This author shows that the installed electrical generating capacity in the region has increased from about 2400 MW in 1980, to about 7100 MW in 2000, while the maximum demand has grown from 1584 to 4772 MW during the same period. It is estimated that the 1998-2208 annual average power demand growth will be 6% (EIA, 2001). Considering the region's large resources, geothermal could contribute significantly to supplying the increasing electricity demands of the future.

Presently, most of the installed electrical generating capacity at the Isthmus corresponds to hydroelectric and thermal plants; the mix varies between countries. According to Montesino (2002), the composition of the installed capacity across the Isthmus changed significantly between 1990 and 2000. During that period, hydro decreased from 66% to 46%; thermal increased from 30% to 48% and renewables from 4% to 6%. In the year 2000, the installed capacity related to all renewable energies (excluding hydro) was below 15% in every country of the region; in Panama and Honduras it was about zero (Figure 3).

In spite of the low capacity numbers for renewables, the high availability factor typical of geothermal power plants has resulted in a significantly larger percent of geothermal electricity generation relative to the percent of installed geothermal capacity. For example in the case of El Salvador, geothermal had 14.3% of the end-of-2001 installed capacity, but supplied 21% of the country's electricity demand in May 2002 (La Prensa Gráfica, June 7, 2002). The same relation is reported for Costa Rica (Moya and Mainieri, 2002).

Until very recently, there was no electrical interconnection between El Salvador and Honduras. Power could only be traded between Guatemala and El Salvador, in the north, and between Honduras, Nicaragua, Costa Rica and Panama, in the south. This changed in mid-June when the Salvadoran and Honduran grids were linked between the 15 de Septiembre and Pavana substations (Figure 4) by a 230 kV line that has a maximum capacity of 100 MW. Now electricity can be traded from one end of the Isthmus to the other.

Within a few years, the situation of the Central American electrical system will be changed significantly by a number of projects. The "SIEPAC Line" (see Appendix A) that would allow the transfer of as much as 300 MW of electric power between the countries is scheduled to be completed in 2006. Discussions continue on the construction of a line tying the electrical grids of Guatemala and southern Mexico; the project could begin as early as 2003. Furthermore, natural gas pipelines originating at southern Mexico and Colombia might be built, although

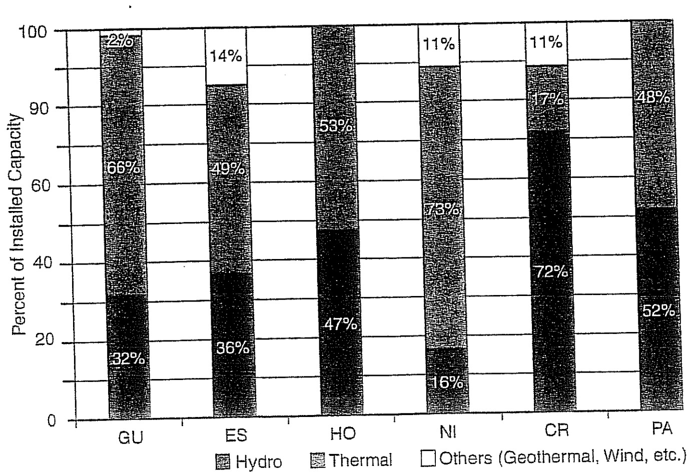
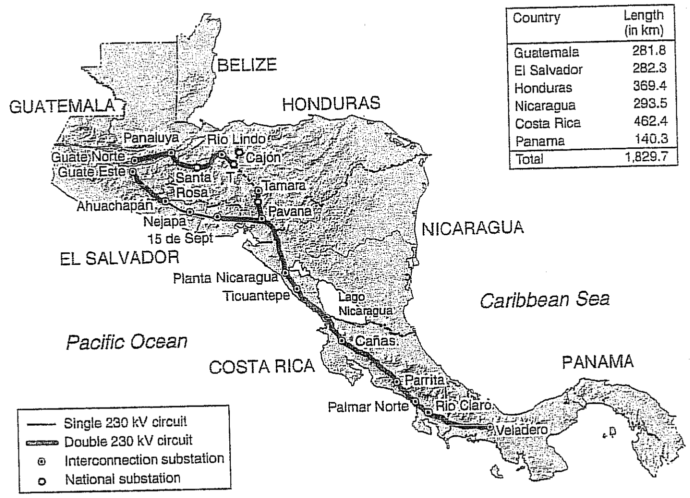


Figure 3. Central America Isthmus electricity sector. Installed capacity by energy source and country in the year 2000. GU: Guatemala; ES: El Salvador; HO: Honduras, NI: Nicaragua; CR: Costa Rica; PA: Panama.



Country	Length (in km)
Guatemala	281.8
El Salvador	282.3
Honduras	369.4
Nicaragua	293.5
Costa Rica	462.4
Panama	140.3
Total	1,829.7

Figure 4. SIEPAC Line. First regional electricity grid for Central America (modified from De la Torre, 2002).

their dates of operation are uncertain (IEA, 2001). These developments are expected to enable continued investment in fossil-fuel power plants, including larger ones with capacities of a few hundred megawatts or more.

A number of companies, mainly from the United States, have begun to expand the capacity of existing power plants and/or to build new ones in the region; all of them will burn some type of fossil fuel. The largest of the new projects is the 780 MW natural-gas, combined-cycle plant that AES is planning to install in Puerto Cortes on the Caribbean coast of Honduras (AES, 2002). Liquid natural gas would be shipped to the site. The construction of special facilities to handle the imported gas would be required, and a 373 km transmission line would have to be build to link the plant with the regional electrical grid. These fossil fuel developments are proceeding in spite of the high cost of generating electricity in thermal plants (recent articles in the Honduran press mention costs of approximately US$ 0.10 per kWh).

Impact of Planned Energy-Related Projects on Geothermal Opportunities

Geothermal activities in Central America have slowed down during last few years in spite of the region's large resources and the benign nature of this indigenous energy source. This is mainly due to economic (low cost of fossil fuels) and political (governments giving priority to other areas) reasons, and by the privatization of the electricity sector.

The construction of new electrical transmission lines, natural gas pipelines and larger thermal plant may further impact the future development of the region's geothermal resources. Once the investments in plants and related infrastructure are made, it is not clear what will occur when the price of fossil fuels keeps increasing (e.g., oil prices reaching US$ 30 or more per barrel), an inevitable fact as the world reserves become smaller and the demand larger (see for example, Meidav, 2001). It is difficult to imagine that the Central American countries and the private companies would abandon the investments that were made. In other words, higher oil and gas prices would result in higher electricity prices to the consumers, an unaffordable situation from both economic and political viewpoints.

The other major source of electricity in the region is hydropower. Rainfall amounts determine how much can be generated by the hydroelectric projects. The region is characterized by periods of droughts and heavy rains. Furthermore, climatic conditions vary not only from year to year, but also from country to country. At present (June 2002), prevailing drought conditions have resulted in low water levels behind many dams of the region relative to previous years. Therefore, the amount of electricity being generated by the thermal (oil-burning) plants is larger than usual; this is reflected in higher monthly electricity bills to consumers. The situation can worsen even further if a new El Niño phenomenon affects the Isthmus. At meetings and in numerous recent local newspapers articles this issue has been discussed not only because it would result in higher electricity bills, but also in smaller or failed crops, and perhaps famine in parts of the region (see for example, CEPREDENAC, 2002).

Summarizing, increased fossil fuel costs and drought conditions would mean more expensive electricity. If that occurs, Central American countries would suffer in terms of their ability to compete in world markets, and governments would be criticized by all sectors of society. Subsidizing the price of electricity is a possible but expensive solution that could not be afforded by most countries of the region. Despite these potential pitfalls of increasing reliance on fossil fuels and hydropower, developers might be reluctant to invest in Central American geothermal projects – typically in the 10 to 50 MW range – in a market that is dominated by large thermal and hydroelectric plants. Considering the time needed to start generating income from a geothermal project (on the order of 3 to 5 years), developers may require concrete evidence from local governments and/or multinational agencies of long-term support of renewable energy projects by way of laws and regulations, and actual policies, like tax incentives, power purchase agreements, carbon credits, etc.

Recommendations

It is still not too late for trade associations and other groups that support geothermal to approach Central American governments to: (1) emphasize the advantages of developing the geothermal resources of the region, (2) stress the immediate environmental and foreign exchange problems, as well as future rising costs and climatic uncertainties associated with large thermal plants and hydroelectric projects, and (3) remind them to put in place legislation that would support and give incentives to projects that use indigenous, renewable energy sources, like geothermal. With the same purpose, meetings should be set up with officials of U.S. and multinational agencies requesting grants, the creation of loan guarantee and carbon credit programs, etc. that would facilitate the development of new geothermal areas in Central America (and elsewhere).

Governments should be reminded that most geothermal projects in the region are being delayed because of lack of clear policies on renewable energy resources and their development for electricity production. These could include tax incentives and/or subsidies for developing indigenous renewable energy sources and the implementation of an active carbon credit market. The need of long-term power purchase agreements that allow the developers to get funding for the large up-front investments of geothermal projects should also be stressed. In the absence of such agreements, subsidies for exploration would be a viable option to increase geothermal development.

In conclusion, the pending changes in the Central American electricity system will not favor renewable energies in general or geothermal specifically. It is imperative to educate Central American governments about the pitfalls in over-reliance on fossil fuel and hydropower projects for the increasing regional power demand. Governments should encourage the development of policies and incentives that foster energy diversification and the long-term energy stability that such diversification brings. These developments would naturally place renewables in a more favorable position, and one of the largest source of renewable power in the region is geothermal. As more decisions are made regarding new fossil-fuel power and hydroelectric plants, and related infrastructure, it will become more difficult to rally the support of government and multinational agencies for new geothermal projects; therefore, time is of the essence.

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APPENDIX A

The SIEPAC Project

Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama signed the Framework Agreement on the Central American Electricity Market ("Tratado Marco del Mercado Eléctrico de América Central"; http://www.siget.gob.sv/tratadomarco.htm) in December 1996; it was ratified in 1998. Under this agreement, the SIEPAC ("Sistema de Interconexión Eléctrica Países América Central") project was initiated (De la Torre, 2002). The two main activities under that system are:

(1) The creation of a Central American wholesale electricity market, the so called "Mercado Eléctrico Regional (MER) and of the regional organizations "Comisión de Interconexión Eléctrica Regional (CRIE) and "Ente Operador Regional (EOR)". CRIE would regulate the market and EOR would be its operator, and

(2) The construction of the first Central American regional electrical transmission system, called "Línea SIEPAC" (Figure 4).

The existence of such a regional electrical interconnection would allow,

(1) construction of larger power plants, reducing the costs per MW installed (i.e., benefits of scale),

(2) trading of electricity at a regional scale and selling of surplus power of individual countries,

(3) improvement of the reliability and quality of service, and

(4) to take advantage of the differences in times of peak demand and climate between countries (i.e., droughts generally do not extend over the entire region).

The construction of the regional transmission system is scheduled to begin in 2003 and be completed in 2006. The cost of the project will be about 320 million dollars; most of the funding will be provided by the Inter-American Development Bank (IDB). The governments of Spain and of the six Central American countries involved (i.e., Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama) will provide the rest.